



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number: 0 541 500 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 92850249.1

(51) Int. Cl.⁵: G05B 19/42, A61C 13/00,
G01B 5/20

(22) Date of filing: 23.10.92

(30) Priority: 01.11.91 SE 9103204

(72) Inventor: Andersson, Matts
Hammarströms Täppa 2
S-443 39 Lerum (SE)
Inventor: Carlsson, Lennart
Matildebergsgatan 36
S-431 38 Mölndal (SE)

(43) Date of publication of application:
12.05.93 Bulletin 93/19

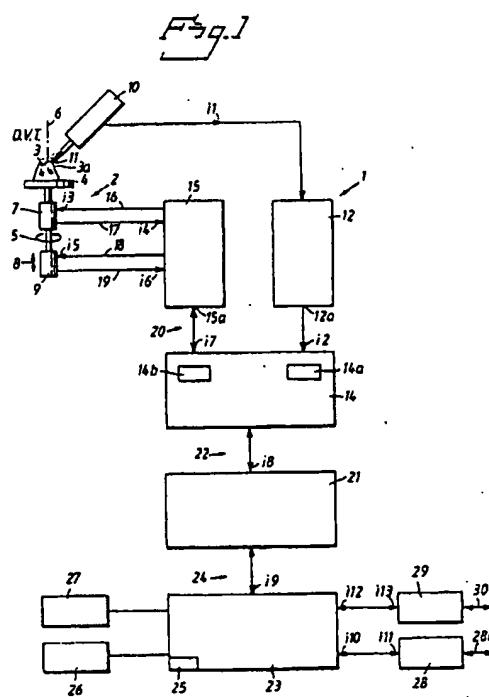
(74) Representative: Falk, Bengt
Bofors AB, Patents and Trademarks
S-691 80 Karlskoga (SE)

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IT LI NL SE

(71) Applicant: Nobelpharma AB
Box 5190
S-402 26 Göteborg (SE)

(54) Scanning device.

(57) A sensing device senses a contour (3a) of a model (3) and generates, in response to the sensing, a representation (11). The representation is used to control tool equipment for producing, for example, dental implants, support members, etc. or tools for producing such implants, members, etc. The representation (11) is fed to computer equipment (23) which generates a signal array (13). This latter effectuates or is included in the control of the tool equipment. The signal array (13) is selected or compressed so that it will be sufficient to enable the tool equipment to perform with its expected degree of accuracy/tolerance in production.



EP 0 541 500 A1

TECHNICAL FIELD

The present invention relates to a device for generating, by means of a scanning function applied to a scannable contour on a model, a representation which may be used for controlling a tool which operates with a high degree of precision in connection with the production of a body, or a tool for such a body, which is to be implanted in a human being. As examples of such bodies, mention may be made of dental implants, support members, etc. The model preferably consists of a three-dimensional model.

BACKGROUND ART

It is known in the art, in the production of replacement parts, support members etc. in the human body, to utilize a copy milling cutter in which a model is applied in the cutter and is sensed and in response to the sensing a tool processes a blank in order to produce from the blank a body or a tool part with the same shape as the model.

Our Swedish patent application No. 9003967-8 describes a system in which the sensing or scanning of the model is separate from the processing equipment and control signals for the latter are generated with the aid of computer equipment.

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

The use of copy-milling cutters has its limitations in respect of production speed. Moreover, there is an additional disadvantage in that the read-off function and processing function must be located in the same premises. The appearance of the model is strictly linked to the structure of the copy milling cutter, which means that variations and additions to the shape of the model in question, enlargements of the contours etc. cannot be put into effect with the desired freedom of choice.

In connection with equipment in which it is desired that the sensing and processing functions be located in different premises, it is a matter of urgency that an expedient read-off function and processing of the thus obtained representation may be put into effect. The representation and the control must be capable of co-ordination so that unambiguous scanning and sensing can be adapted to an optimum or to the greatest possible extent minimized control signal function.

The quantity of read-off data/information should be kept to a minimum so that the processing and selection functions in the computer equipment may be simplified/reduced while retaining the accuracy of control. The scanning and sensing principles and storage function in the data processing equipment are

therefore of crucial importance in this context.

In the case when a telecommunications medium (e.g. communication via the public telephone network) is to be employed to transmit information from one place to another, it is vital that the quantity of requisite control signals can be reduced. In addition to operating with small scanning and processing quantities, it may be relevant to extract by means of data processing equipment characteristic parts of the read-off information and to transmit these characteristic parts via the medium, and also reconstruct replicas on the reception side with the aid of the above-mentioned characteristic parts so that sufficient control signals for the accurate control of the tool equipment can be obtained.

In the scanning and sensing function with contact devices/ sensing signals, it is also essential for the shape of the organ in the part co-operating with the contour to be put in relation to the shape of that part of the tool by means of which a blank is processed. An optimum relationship leads to significantly reduced read-off and processing information.

It is also essential for the sensing and control functions to be related to one another without the quantity of processed data or information growing in the data processing equipment. A relationship between read-in and read-out of information entered in the computer must also be established in such a manner that, for example, the read-off function will be separated from the read-in function so that the control generation causes the processing function to be carried out more quickly than the read-out function.

In one embodiment, the present invention will comprise a contour sensing portion interactable with the contour and having a curved surface which may be brought into abutment against the surface of the contour. The dimensions of the curved area, e.g. a spherical area, are to be put into relation with the details of the contour so that a reduced sensing degree (resolution) is obtained.

The tool equipment must, for example in the production of dental implants, bridges, etc., be capable of working to a degree of accuracy/tolerance of one or a few hundredths of a millimetre (e.g. 0.01-0.09 mm). The resolution on scanning may in one embodiment (e.g. scanning by laser) be appreciably greater, e.g. one or a few thousandths of a millimetre.

SOLUTION

One object of the present invention is int. al. to solve the above-outlined problem structure and that which may then substantially be considered as characterizing the novel apparatus according to the present invention is that the representation may be entered into computer equipment which generates a signal array that effectuates or is included in the control of the tool equipment, and that the sensing and/or a

selection function effectuated by the computer equipment of the representation is or are selected so as to ensure an order of magnitude of the signal array which, from the sufficiency viewpoint, satisfies the degree of accuracy with which it is expected that the tool equipment will perform.

In one embodiment, the sensing function operates with a first member co-operating with the contour, e.g. a needle. In its portion co-operating with the contour, the member displays a first form which substantially corresponds to a second form of a second member which is included in the tool equipment and which interacts, with a portion carrying the second form, with a blank in the production process. The said portion may consist of a milling cutter. In one embodiment, said first and second forms are substantially spherical. In addition, the sensing function and the processing function of the tool equipment are mutually co-ordinated so that a linear transmission function arises. The sensing function and the processing function may then operate at different speeds. It is thus of interest in this art that the speed of the processing function may exceed the sensing function.

The computer equipment is preferably designed with memory means in which the representation or information of significance for the representation is stored. The memory may, for instance, consist of a magnetic internal or primary memory of the RAM type. In that case when information is to be stored, a secondary memory may also be employed. As example of a secondary memory, mention may be made of a memory of the permanent magnet type. The read-in function of the information is then preferably separated from its read-out function so that, for example, control signal generation may be carried out more rapidly than the read-in of the representation.

In one embodiment, the sensing function takes place on models of soft or brittle material, for example plaster. With the aid of the tool equipment, bodies or tool parts may be made completely or partly of hard, soft or brittle material.

In one embodiment, compression takes place in the computer equipment of first information referable to the representation on the formation of second information referable to control of the tool equipment. The first and/or second information may be stored in storage devices on delayed transmission of the control information, e.g. via a telecommunications medium (for example the public telephone network). The storage devices may then be designed with a capacity which entails storage of the information from sensing of one or more contours. In one embodiment, the storage devices have a capacity of at least 2-3 megabyte.

In one embodiment, the sensing function is carried out during rotation of the model with simultaneous mutual relative displacement between the model and a sensing device. The sensing function is execut-

ed a large number of times per revolution, e.g. 360 times per revolution. The relative displacement may be selected to be approx. 0.1 mm/revolution. Only characteristic parts of the representation and/or control can, in one embodiment, be transmitted on the employed telecommunications medium. A replica of the control/control signals is generated at a reception point with the aid of the characteristic parts.

The present invention also utilizes known mathematical principles in the compression function.

ADVANTAGES

As a result of the proposals disclosed in the foregoing, a considerable reduction may be achieved in the quantity of information which is obtained in the sensing function. The capacity and space on the computer equipment may then be kept to a minimum, at the same time as transmission via the relevant link is simplified/shortened in terms of time. The sensing and control signal-generating functions may be kept separated and processed independently of each other. A plurality of sensing stations may be connected to the same computer equipment and similarly a plurality of sensing and computer equipment units may be connected to one and the same tool equipment via the same or different connections. The information quantities may be reduced substantially, which gives short processing times in the computer equipment and transmission of a relatively small quantity of control information. The proposed principles also afford the possibility of so-called contact-free sensing in which the sensing function more exactly and in greater detail senses the contour in question. The representation obtained from the sensing function can be reduced/compressed in the computer equipment with the aid of the above-mentioned selection function. As a result of the proposed spherical shape of the abutment portion of the sensing device against the contour, sensing of soft and/or brittle models can be carried out. In that the shapes of the sensing and processing device are designed to be substantially identical, complicated calculated functions referable to the actual and sensed contour of the model in question are eliminated. As a result of the proposed structure, the processing capacity in the computer equipment may be reduced by one third and savings of the space/volume of the computer equipment may be reduced by up to one fifth.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

One currently proposed embodiment of an apparatus which displays the characteristics significative of the present invention will be described in greater detail hereinbelow, with particular reference to the accompanying Drawings. In the accompanying Draw-

ings:

Fig. 1 shows in block diagram form the structure of the sensing device with computer equipment (PC), programmable input and output circuits, control unit for signal emission and signal sensing units in which the signal emitting unit controls a model carrying unit so that this moves in relation to a sensing unit that emits signals to the above-mentioned signal sensing unit;

Fig. 2 shows, on a larger scale and from the side, how a sensing portion in a sensing unit interacts with the contour of a model;

Fig. 3 shows from the side how a blank is processed by means of a tool equipment part, by means of which the contour in Fig. 2 is produced from the blank on reduced, equal or enlarged form;

Fig. 4 shows on a larger scale the interaction between the sensing portion and the contour of the model; and

Fig. 5 shows in table form how the sensing proceeds in the embodiment according to Fig. 4.

DETAILED DESCRIPTION OF EMBODIMENT

Referring to the Drawings, in Fig. 1 a read-off device is given reference No. 1 and comprises int. al. a mechanical unit 2 on which a model 3 may be secured on a rotatable device 4. In addition to being rotatable in the direction of the arrows of rotation 5 (counter-clockwise and clockwise) about an axis of rotation 6 by means of a motor 7, the device 4 and the drive motor 7 are longitudinally displaceably disposed in the directions 8 of the axis 6. By this means, the model 3 will also be longitudinally displaceably disposed in said directions 8. The longitudinal displacements are realized by means of a motor 9. A sensing unit 10 which is fixedly disposed in relation to the model is provided with a device 11 which may be resiliently brought into contact against the contour 3a of the model 3. When the model is turned and displaced in relation to the unit 10 and the device 11 in connection with the activations of the motors 7 and 9, there will be received from the output of the unit 10 a representation in response to sensing by the device 11 of the contour 3a, the representation being in the form of one or more electric signals i1. The latter signal or signals are processed in a signal processing unit 12. Processing in the unit 12 entails that the representation i1 is sampled and that digital signals i2 are obtained from the output 12a of the unit 12 in response to the samplings. The digital signals can be transmitted on a bus connection for parallel transmission of 16 bits. The unit 12 is, via the bus connection, connected to a control unit 14. The above-mentioned motors 7, 9 are controlled by means of a combined unit 15 for driving, speed adjustment and positioning of the motors. The control functions for the motors operate with

feedback function and the control and feedback conductors are indicated by reference numerals 16, 17; and 18, 19, respectively, and the set and actual value signals are indicated by i3, i4; and i5, i6, respectively.

5 The unit 15 is connected via inputs and outputs 15a to the control unit 14. The connection is designed as an additional bus connection 20 for 16-bits parallel transmission. The control unit comprises first and second units 14a and 14b which serve units 12 and 10 15 respectively. Control of the motors 7 and 9 is related to the sensing and the representation i1 for this.

The sensing device includes a programmable interface 21 with read-in and read-out devices which are connected to the control unit 14 via a bus connection

15 22 for 24-bits parallel transmission. A data processing equipment, e.g. a PC 23, is connected to the read-in and read-out devices 21 via a bus connection, e.g. an AT bus connection. The PC may be of type AT-286 which includes one or more magnetic internal

20 memories 25 or primary memories of the RAM type. The computer 23 is also fitted with a secondary memory 26, 27 of the permanent magnet type. A memory 26 may consist of a hard disk and a memory 27 of a floppy disk.

25 The signals on the bus connection 20 are shown with reference numeral i7, on the bus connection 22 with i8 and on the bus connection with i9. The computer 23 is connected to or provided with a data communication port 28 via which the control/representation information may be entered into and retrieved from the read-off device via an input and output 28a to and from another data processing equipment or data communication (not shown). Moreover, the computer 23 is connected to a modem 29 via which the computer may be connected to a telecommunication connection 30 in a telecommunications network, for example the public telephone network. Information to and from the connection 30 via the modem 29 is indicated by reference numerals i12 and i13 respectively.

30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910

case. The spherical shape is indicated by reference numeral 33.

In Fig. 3, a blank is indicated by reference numeral 34. The blank, which may be of titanium, cemented carbide, alloy, graphite, etc., must be provided with a contour 3a and 3a' in Figs. 1 and 2 corresponding to contour 3a'. The blank 34 is processed or treated with a tool 35 which, in the present embodiment, consists of a milling cutter. The forward portion 36 of the tool has a shape 37 which substantially, preferably exactly, agrees with the shape 33 of the read-off device 32 according to Fig. 2. The tool/milling cutter is disposed in a per se known manner in a spindle and the tool includes a tool adjustment control portion 38 which receives control signals i14 via the telecommunication connection 39 (cf. 30 in Fig. 1) and a modem 40 which interacts with the modem 29 according to Fig. 1. Via the modem 40, control signals i14' are fed to the control portion 38.

Figs. 4 and 5 show the read-off principle, read-in and read-out into and from, respectively, the memory of a computer of sensed values and entered values V, respectively. The model 3" is rotated about its axis 6' and sensing takes place in different angles φ . In the example, sensing takes place for each degree, i.e. 360 times per revolution and the read-off angles are indicated by 0-360°. The read-off points are symbolized by reference numeral 41. For each revolution (360°), the model moves in a Z direction in relation to the read-off portion 33', 33", these positions each representing their location in relation to the model 3". For every revolution that the model rotates, a relative movement S (= pitch) between the model and the sensing portion in the present embodiment is 0.1 mm. In the table according to Fig. 5, the pitch Z for each degree φ is 0.1 mm/360. Other pitches S and number of sensing points may be employed within broad limits.

In the table IS indicates a read-in sequence in the memory of the computer and US a read-out sequence from the memory. V represents read-in/readable value for each degree. The values V occur in binary form or other suitable form. The sequences IS and US can be executed in a per se known manner at different speeds. The sequence US is preferably higher than the sequence IS.

The sensing surface 33 of the sensing portion 32 displays a radius R which may lie within the range of between 0.5 and 2.0 mm and is preferably 1.0 mm. This size of the radius is suitable on production from models which represent a dental implant, bridge, etc. The sensing surface 33 is thus selected so as to give a reduced sensing degree/resolution in relation to the true detailed shape of the contour.

One method of compressing the entered data quantity is to approximate a number of points by means of a function, e.g. a polynom of the third degree ($c_1 + c_2x + c_3x^2 + c_4x^3$). The total computer quan-

tity is divided into groups. Each such group is approximated by a function. So instead of transmitting pure measurement data from the read-off unit to a relevant factory computer, the coefficients of the function are transmitted for each group (c_1, c_2, c_3 and c_4 in the case employing a polynom of each degree).

Since both functional value (indicator signal) and the distance between each read-in is known, i.e. $f(x)$ and x in each group when the function is a function of a variable, the function may be approximated by the least square method. The solution in the sense of the least square method to the above equation system $Af = f$ is given by the solution to the equation system $Au^T A f = A u^T f$. If $Q(x)$ is the indicator signal at a given position and $f(x)$ is the approximated value at the same point, the error can be calculated with $\text{error}(x) = f(x) - Q(x)$. The number of values included in each group to be approximated by a function must be adapted such that the error ($\text{error}(x)$) is less than the largest permitted error for all values in the group. The above mathematical processing is carried out in the computer in a per se known manner.

The present invention should not be considered as restricted to that described above and shown on the drawings, many modifications being conceivable without departing from the spirit and scope of the appended Claims.

30 Claims

1. An apparatus for generating, by means of a sensing function applied to a contour (3a) of a model (3) which may be sensed, preferably a three-dimensional model, a representation (i1) usable for controlling tool equipment (35) working with a high degree of precision for producing a body usable in a human being, e.g. a dental implant, support member, etc., or a tool part for said body characterized in that the representation (i1) may be applied to computer equipment (23) which generates a signal array (i13) which effectuates or is included in the control of the tool equipment (36); and that the sensing and/or selection function effectuated by the computer equipment of the representation is/are selected so as to ensure an order of magnitude of the signal array (i13) which satisfies, from the sufficiency viewpoint, the degree of accuracy with which the tool equipment is expected to perform.
2. The apparatus as claimed in Claim 1, characterized in that the sensing function operates with a first device interactable with the contour; and that the device displays, at its part interactable with the contour, a first form which substantially corresponds to a second form of a second device included in the tool equipment and which interacts

- with a part carrying said second form with a blank in the production process for the body and the tool part respectively, said first and said second forms preferably being substantially spherical.
3. The apparatus as claimed in Claim 1 or 2, characterized in that the sensing function and the processing function of the tool equipment are mutually substantially co-ordinated.
4. The apparatus as claimed in any one of the preceding Claims, characterized in that the sensing function and the processing function of the tool equipment operate at different speeds, preferably such that the speed of the processing function exceeds, for example significantly, the speed of the sensing function.
5. The apparatus as claimed in any of the preceding Claims, characterized in that information significative of the representation is storable in the computer equipment, in a memory associated therewith, for example in a magnetic internal (primary) memory of the RAM type and/or a secondary memory of the permanent magnet type; and that the read-in function of such information is separated from its read-out function.
6. The apparatus as claimed in any one of the preceding Claims, characterized in that the sensing function is carried out on a model of soft or brittle material, e.g. plaster; and that bodies are produced by means of the tool equipment completely or partly of cemented carbide or ceramics, or a tool part for whole or partial production of bodies (tool parts) of hard, soft or brittle material.
7. The apparatus as claimed in any one of the preceding Claims, characterized in that compression takes place in the computer equipment of first information referable to the representation on formation of second information referable to the control of the tool equipment, and/or that the first and/or the second information may be storable in storage means, e.g. buffer means, memory means, etc., in order to realize a time lag between the sensing and/or control functions in relation to a transmission function, e.g. effectuated on a telecommunications medium, of the control to the tool equipment.
8. The apparatus as claimed in Claim 9, characterized in that the storage devices store the representations for one or more contours for transmission via a telecommunications medium at off-peak hours thereon, and that said storage devices have a capacity of at least 2-3 megabit.
9. The apparatus as claimed in any one of the preceding Claims, characterized in that the sensing function is of the type which senses the contour during rotation of the model with simultaneous mutual relative displacement between the model and the sensing device, and/or that the sensing takes place a large number of times per revolution, e.g. approx 360 times per revolution, and that the relative displacement is approx. 0.1 mm/revolution.
10. The apparatus as claimed in any one of the preceding Claims, characterized in that characteristic parts of the representation and/or the control are selected prior to the transmission on a telecommunications medium; and that a replica of the control is generated at a reception site with the aid of the characteristic parts.
15. The apparatus as claimed in any one of the preceding Claims, characterized in that to the computer equipment (23) are connected via an interface (21) comprising programmable input and output circuits, which are connectable to a control unit (14) which in turn is connected to a signal generation unit (15) for model movement actuating means (7, 9) and to a unit (10, 11) converting the shape of the contour (3a) into electrical signals (11).
20. The apparatus as claimed in any one of the preceding Claims, characterized in that the sensing surface (33) of the sensing portion (32) displays a radius (R) in the range of between 0.5 and 2.0 mm in connection with a model (3) which represents a dental implant, bridge; etc.
25. The apparatus as claimed in any one of the preceding Claims, characterized in that the sensing surface (33) of the sensing portion (32) is selected so that it gives a reduced sensing degree/resolution in relation to the true detailed form of the contour (3a).
30. The apparatus as claimed in any one of the preceding Claims, characterized in that the read-in or read-off data quantity will be compressed by means of an approximation of a quantity of read-in or read-off points with a function, e.g. a polynomial of the third degree.
35. The apparatus as claimed in any one of the preceding Claims, characterized in that the read-in or read-off data quantity will be divided into groups; that each respective group is approximated with a function; and that the coefficients of each respective function are transmitted between relevant communication parts, e.g. from

the read-off unit to a factory computer, as representation of the pure/total quantity of read-in or read-off data.

16. The apparatus as claimed in any one of the preceding Claims, characterized in that by utilizing the knowledge that the value of each respective function, i.e. the indicator signal or sensing, and each respective distance between each respective read-in, is known, each respective function will be approximated using the least square method.

6

10

17. The apparatus as claimed in any one of the preceding Claims, characterized in that the error between the actual indicator signal and each respective approximated value is calculated, and also the number of included values in each respective group of said groups which is to be approximated with a function will be adapted such that the absolute value error is less than the largest permitted error for all values in the group.

15

20

25

30

35

40

45

50

55

7

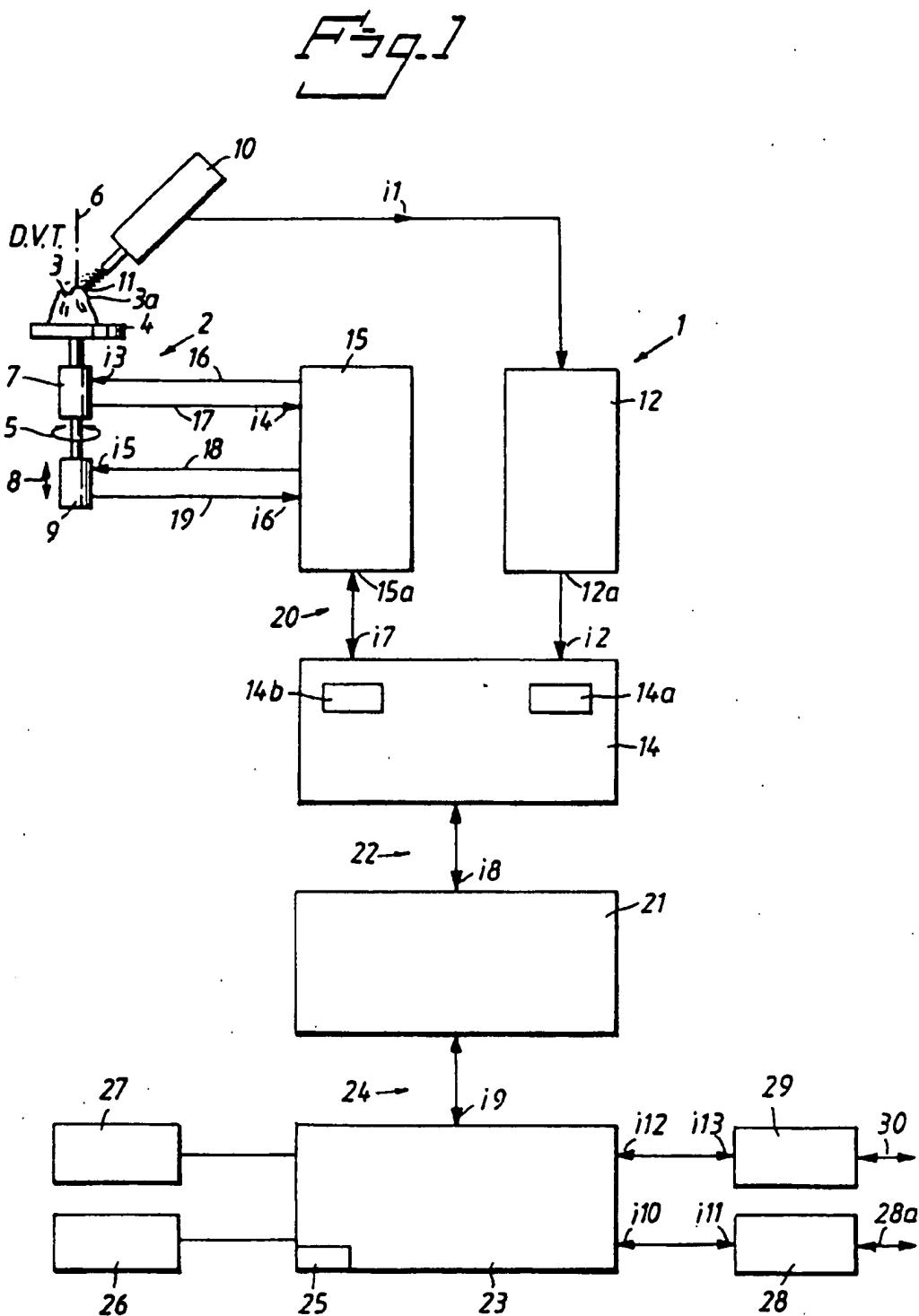


Fig. 2

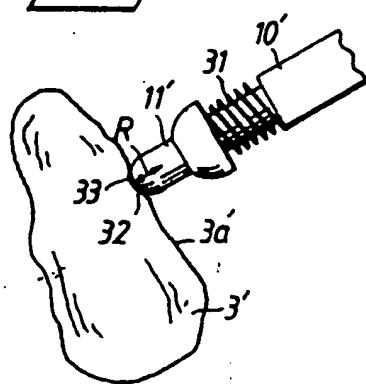


Fig. 3

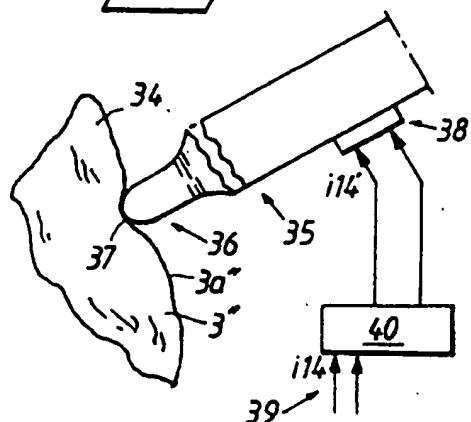


Fig. 4

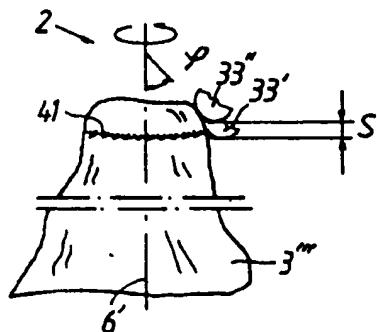


Fig. 5

IS	Z	φ°	V	US
→	$S0/360^\circ$	0°	100110010111	←
→	$S1/360^\circ$	1°	110101010101	←
→	$S2/360^\circ$	2°	111011101111	←
→	$S3/360^\circ$	3°	110100010110	←
→	$S4/360^\circ$	4°	111101001001	←
→	---	---	---	→
→	---	---	---	→
→	$S360/360^\circ$	360°	11011011101101	←



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 85 0249

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	G05B19/42 A61C13/00 G01B5/20
X	US-A-4 997 369 (AARON SHAFIR)	1,4-6,9	G05B19/42 A61C13/00 G01B5/20
Y	* column 3, line 35 - line 67; figures 1,2 *	7,8,11, 14	
A	* column 5, line 31 - column 9, line 64; figures 8-13 *	12,13	

Y	ASSOCIATION FOR INTEGRATED MANUFACTURING TECHNOLOGY - 22ND ANNUAL MEETING & TECHNICAL CONFERENCE PROCEEDINGS 14 May 1985, ST. LOUIS, MO. HIDEMASA IIDA ET AL. 'Cam Station and Part Drawing Reader with 32-Bit Microprocessors'	7,8,11, 14	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	* page 17 - page 26 *	12,13	
X,P	EP-A-0 455 855 (SIEMENS AKTIENGESELLSCHAFT)	1-6,9	
A,P	* the whole document *	7,8	

Y	ROBOTICS AND COMPUTER-INTEGRATED MANUFACTURING vol. 5, no. 2-3, 1989, pages 173 - 181 G. PRITSCHOW, G. GRUHLER 'AUTOMATIC PROGRAMMING OF INDUSTRIAL ROBOTS BY SENSOR GUIDANCE'	1-3,6, 15-17	G05B A61C G01B
Y	EP-A-0 420 990 (FANUC LTD) * column 3, line 10 - column 4, line 40 *	1-3,6, 15-17	

The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		18 FEBRUARY 1993	PANDOLFI C.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : member of the same patent family, corresponding document			